Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal Form

Section 1. General administrative information

Path-Uw Technical Support

Bonneville project number, if an ongoing project 9700200

Business name of agency, institution or organization requesting funding
University of Washington

Business acronym (if appropriate)

Proposal contact person or principal investigator:

Name	James J. Anderson
Mailing Address	1325 - 4th Ave., Suite 1820
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Phone	206-543-4772
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Subcontractors. List one subcontractor per row; to add more rows, press Alt-R from within this table

Organization	Mailing Address	City, ST Zip	Contact Name
Evans-Hamilton Inc.	4608 Union Bay Plaza NE	Seattle, WA 98105-4026	Curtis Ebbesmeyer

NPPC Program Measure Number(s) which this project addresses.

NMFS Biological Opinion Number(s) which this project addresses.

Other planning document references.
If the project type is "Watershed" (see Section 2), reference any demonstrable support from affected agencies, tribes, local watershed groups, and public and/or private landowners, and cite available documentation.

Subbasin.

Short description.
Provide tools and analyses for the scientific, ecosystem-based evaluation of management actions and hypotheses through statistical and mechanistic models of anthropogenic and environmental factors.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction	+	Watershed
	Resident fish		O & M	+	Biodiversity/genetics
	Wildlife		Production	+	Population dynamics
+	Oceans/estuaries	X	Research	X	Ecosystems
+	Climate	+	Monitoring/eval.	+	Flow/survival
	Other	+	Resource mgmt	+	Fish disease
			Planning/admin.	+	Supplementation
			Enforcement		Wildlife habitat en-
			Acquisitions		hancement/restoration

Other keywords.
life history, modeling, bubble disease, ecological interactions.

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
8910800	Monitoring and Evaluating Report	Develop the models used in PATH analyses.
9600600	PATH - Facilitation	Part of PATH

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Participation in PATH meetings & Workshops		
2	Hypotheses on Smolt Passage & delayed mortality		
3	Hypotheses on upstream passage		

4	Hypotheses on spawning & fry emergence		
5	Effects of envinronmental conditions on smolt estuary/ocean entrance		
6	Effects of migration on ocean harvest		
7	Hypotheses on disease stress and vitality		

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	9/1997		15.00%
2	9/1997		10.00%
3	9/1997		10.00%
4	9/1997		.10
5	9/1997		20.00%
6	9/1997		20.00%
7	9/1997		.10
			TOTAL 95.00%

Schedule constraints.

Completion date.
2003

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		$144,500
Fringe benefits		$28,947
Supplies, materials, non-expendable property		$5,561
Operations & maintenance		$11,678
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	lease	$16,483
PIT tags	# of tags:	
Travel		$6,299
Indirect costs		$56,541

Subcontracts		$26,000
Other	tuition fees	$6,280
TOTAL		$302,289

Outyear costs

Outyear costs	**FY2000**	**FY01**	**FY02**	**FY03**
Total budget	$300,000	$300,000	$300,000	$300,000
O&M as % of total	39.00%	39.00%	39.00%	39.00%

Section 6. Abstract

University of Washington Support of the Plan for Analyzing and Testing Hypotheses (PATH).

The overall goal is to assist the region in developing the ability to identify and assess key alternative hypotheses relating to salmon stock recovery and rebuilding in the Columbia River ecosystem. This project will provide tools and analyses for the scientific ecosystem-based evaluation of the impacts of specific fish and wildlife program actions.

Specific objectives of this project are the development and use of statistical and mechanistic models of salmon life-cycle stages in various habitats: the mainstem (including passage of juveniles and adults), tributaries, estuary, and ocean. Both anthropogenic and environmental factors at each salmon life stage will be approached in a multi-faceted fashion involving qualitative descriptions, statistical data analysis, Bayesian maximum likelihood estimation techniques, and mechanistic models. Through these approaches, alternative hypotheses will be tested according to their mathematical rigor, the realism of their ecological mechanisms and their ability to fit available data and data patterns.

An important outcome will be the development of tools to assist managers in assessing the strategic implications and validity of management decisions. The results will include reports describing hypotheses and their evaluations and models which will be available through the World Wide Web that managers can use to evaluate actions.

Section 7. Project description

a. Technical and/or scientific background.

Different modeling systems have evolved to address recovery planning and rebuilding assessment for Columbia River salmon stocks. State and tribal fishery managers developed the FLUSH/ELCM model system, the federal fishery managers, federal hydropower operators developed the CRiSP/SLCM model system. In 1992, the groups reached consensus and implemented a coordinated, peer reviewed effort to address the analytical needs of the region with respect to Columbia River salmon recovery and

rebuilding. Toward accomplishment of this goal, a regional Analytical Coordination Work Group (ANCOOR) was established, including members of the following agencies: Columbia Basin Fish and Wildlife Foundation (CBFWF), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), Idaho Department of Fish & Game (IDFG), Columbia River Inter-Tribal Fish Commission (CRITFC), National Marine Fisheries Service (NMFS), Bonneville Power Administration (BPA) and its contractors, U.S. Army Corp of Engineers (USACE) and the Northwest Power Planning Council (NWPPC).

A scientific peer review of the models panel (SRP) of academic experts funded by BPA during FY 1994 and 1995 recommended that model review and comparison should be focused on hypothesis formulation and testing to resolve crucial differences in assumptions and data interpretation. Initiated by written directives, PATH responds to periodic meetings with senior management and policy personnel in NMFS, BPA, NWPPC, WDF, ODFW, IDFG, US Fish and Wildlife Service (USFWS) and CRITFC.

Realizing the region benefits significantly from a coordinated and consistent approach to technical analyses supporting salmon rebuilding and recovery efforts, the NWPPC (Ibid., Sec. 7.3) called for "....a process to provide for continuing review, coordination and development of analytical tools to assist decision making, facilitate program evaluation and identify critical uncertainties. PATH evolved to provide the region the best available scientific methods and information in the analyses supporting recovery/rebuilding efforts.

This University of Washington (UW) project has been central to the development and evaluation of models in PATH. The CRiSP smolt passage model, developed at UW with earlier funding by BPA, has been one of the two evolving model systems used in PATH. The UW has also developed other model that complement the passage model by addressing different salmon life history stages including; harvest, adult passage, river water quality, fry emergence, fish stress and effects of climate and hydro-system development on productivity.

For long term recovery and sustainability of salmon in the Columbia/Snake River System and the Northwest in general, evaluations of actions must take an ecological perspective. These individual models provide a mathematical foundation in which to structure and view the ecological processes affecting salmon. The models provide the essential mechanistic link between the qualitative descriptive understanding of the ecosystem and the statistical evaluation of data that often reveal complex multi-factor responses of the system to environmental and anthropogenic influences. The models are an essential component to the understanding and management of the system since statistically observable correlations alone may be spurious or ecologically irrelevant and may lead to scientifically unsound management programs.

Details of the significant contributions to PATH studies follow:

The UW provided diagnostics of the smolt passage and survival through the hydrosystem using the CRiSP 1.5 passage model. The model parameter estimates were updated by a review of all hydrosystem data on smolt passage. A comparison of the model predications to observed data were made in the following areas: water travel time, fish travel time, fish survival.

The life-cycle model (the alpha model) was reviewed and comments were provided to PATH

A life-cycle model, the delta model, was developed as an alternative to the delta model. In this life cycle elements are characterized for individual regions and do not require assumptions on the similarities of ocean survival of stocks from different regions. The mathematics of the model and characterization of delayed mortalities in transport and non-transported groups were resolved.

A hypothesis was developed characterizing the impacts of stress in fish passage and transportation on delayed mortality. Measured by descaling were investigated and a model defining the ratio of delayed mortalities of transported and non-transported fish was developed. This analysis is critical to assessing the efficacy of transportation as a recovery measure.

Tree-ring data were collected from the International Tree-Ring data base and analyzed. Decadal cycles in the Western Junipers corresponding closely to the PAPA drift, and indicator of climate change in the eastern Pacific. The tree-rings provide evidence of strong decade-long cycles in the Pacific Northwest over the last 500 years. The data have been used to estimate the next regime shift to be more favorable for salmonid production in the Columbia Basin.

Nearshore oceanographic data were collected from the NOAA buoy database, and oceanographic and river flow records to identify how the Columbia River seasonal flow patterns and the decadal shifts in oceanographic conditions. These data were used to estimate the timing of the regime shift and to simulate regime shifts prospectively.

The influence of anthropogenic and natural environmental cycles on the decline of Columbia/Snake river stocks was addressed. A review of the history of the hydrosystem development and climate cycles over the past century reveals that a fish-favorable climate masked detrimental effects of construction during the major development phases of the hydrosystem while a fish-unfavorable climate since 1977 has counteracted fish recovery efforts. These observations have been disseminated as: 1) Anderson, J. J. (in press). Decadal climate cycles and declining Columbia River salmon. Sustainable Fisheries Conference Proceedings; 2) Anderson, J. J. 1997. Decadal Scale Climate Pattern and Salmon Survival: Indicators, Interactions and Implications, Estuarine and Ocean Survival of Northwest Pacific Salmon Workshop NMFS 1997.

b. Proposal objectives.

Specific objectives.

Objective 1. Participation in PATH meetings and workshops

Although objectives for PATH are dictated through an evolving process based on directions from managers and results of previous PATH analysis, several major issues are anticipated to be of importance and will be explored as hypotheses in the near future. Listed below, these issues involve model and analysis tools that currently exist or that will be developed in 1998 and will be available in 1999.

Products: PATH reports.

Objective 2. Smolt passage and delayed mortality

Issues of smolt passage and the connection of smolt history and delayed mortality of transported and non-transported fish will be continued. Hypotheses will evolve through the PATH process and cannot be explicitly stated at this time. Issues of focus may include: impacts of cumulative stress from dam passage and water quality issues, impacts of growth and bioenergetics considerations.

Products: PATH report and hypotheses on factors affecting smolt passage and delayed mortality.

Objective 3. Adult upstream passage

The upstream passage model will be brought into the PATH process to assess hydrosystem impacts on adults and the consequences on lifecycle processes. Hypotheses will be developed relating adult migration and bioenergetics to flow, water quality, hydro operations and fish condition. Hypotheses on the impacts of harvest and bioenergetics and spawning success will be investigated.

Products: Report to PATH on adult passage with a model calibrated and validated for chinook and steelhead, evaluating the impacts of hydrosystem operations (spill, flow, drawdown and dam removal) and river harvest on passage.

Objective 4. Spawning and fry emergence

Impacts of drawdown on creation of spawning grounds and on the success of fry emergence will be addressed. The analysis will use the HEC-6 open channel flow numerical model that is designed to simulate changes in river profiles resulting from scour and depositions of sediments. Hypotheses: impacts on redd creation will be describe through the HEC-6 sediment transport model. Fry emergence will be addressed following the bioenergetic modeling work of Beer and Anderson (1997). In this hypothesis temperature and flow effect fry: success of emergence, timing of emergence and size at emergence.

Products: The HEC-6 open channel flow sediment movement model configured for the Columbia and made available to PATH for analyses. Reports on the results of the HEC-6 analysis on redds impacts will be produced.

Objective 5. Effects of environmental conditions on smolt estuary/ocean entrance

The impacts of environmental conditions on survival of smolts in the estuary and early ocean entry are critical to resolve the processes controlling delayed mortality of smolts.

Hypotheses: salmon survival depends on interactions of food and predators when smolts enter the ocean/river plume. Predators include birds in the estuary and fish in the ocean, chiefly mackerel. A match or mismatch between predator and prey can have a major impact of survival and ultimately on stock recruitment. The match or mismatch depends on climate/ocean/estuary conditions prior to and during the smolt migration.

Products: A report on the hypotheses of control of early ocean survival through a climate/predator interaction. The report will detail existing information and outline studies to further test the model and its management implications.

Objective 6. Effects of fish migration on ocean harvest

Hypotheses: Salmon harvest depends on the movement of stock between fishing regions within seasons. These movements can be characterized in terms of movement matrices based on CWT data or on individual-based salmon movement algorithms. Harvest can be minimized on endangered stocks with a stock selective model being developed under project 891080.

Products: A report on the effectiveness of stock specific harvest.

Objective 7. Disease, stress and vitality

Evaluation of the importance of fish condition on fish survival will be a significant issue. Hypotheses: factors affecting smolt condition include disease, stress during river passage due to dam passage, exposures to high temperatures and gas supersaturation effects. Smolt mortality involves the cumulative exposure to multiple stressors which can be addressed through a first-principles model based on organism vitality. (Anderson 1992 and Anderson, in review).

Products: Report evaluating the impacts of fish condition and disease on smolt survival. Ph.D thesis on modeling fish disease.

c. Rationale and significance to Regional Programs.

In general the region is using PATH to ensure that salmon recovery efforts are guided by scientific information. This scientific approach is a stated goal of the Fish Wildlife Program (FWP). Rationales for the Project Objectives in light of the purpose of the PATH process are below. All objectives are developed in cooperation with other members of the PATH groups from the state, tribal and federal agencies.

Objective 1 addresses the effort in a general sense. The proposal is directly connected with all proposals from other PATH participants.

Objectives 2 and 3 relate to the FWP goals to optimize water resources and hydro-operations including drawdown and transportation.

Objective 4 relates to the council need to evaluate the impact of drawdown and dam removal. Working agreements are being made with USACE and their contractors to obtain current information on sediment modeling. This will be subsumed into the PATH process by making calibrated and validated sediment models and the implications to fish dynamics available.

Objective 5 relates to the U.S Congressional directive to consider the impacts of ocean conditions on stocks. Arrangement have been made with J. Ingraham of the NMFS Sand Point Laboratory, D. Hankin of Humbolt University to convene a working group to address the issue. Our work will be synergistic with the FWP project Assess Impacts of Hydro Development on the Estuary.

Objective 6 relates to the need for fishery managers to develop stock selective harvest policies. This tool will allow PATH to evaluate possible effectiveness of stock selective harvest policies for fall chinook.

Objective 7 relates to the smolt conditions and will provide a mechanistic structure in which to evaluate the impacts of stress and physiological status of smolts on their survival during migration. Working arrangements have been made with the USACE dissolved gas studies and the USFWS disease projects at the Seattle Sand Point Laboratory. This project has the potential to identify points in the salmon life cycle where interventions could aid in reduction of disease (such as Bacterial Kidney disease) induced mortality.

d. Project history

The UW technical support to PATH is going into its second year. Project reports include various internal PATH reports and contributions to Chapters 5, 6 and 12. Numerous internal PATH documents were developed including; Analysis of ocean indicators, documentation of the delta life-cycle model, evaluation of effects of descaling on smolt passage and survival. The major achievements were in developing the alternative lifecycle model for PATH, updating the PATH with information on ocean cycles and their impact on fish, and developing a new methodology to assess the impact of cumulative fish stress on delayed mortality in both in-river and transport passage of smolts.

Project reports and technical papers: Anderson (1996a, 1996b, in press (2), 1997), Anderson and Hinrichsen (1996, 1997a, 1997b 1997c), Anderson et al. (1997), Hayes (1997), Hinrichsen et al. (1997), Shaw (1996, 1997), Zabel (1996, 1997a, 1997b).

e. Methods.

In general, the contributions to UW projects to PATH will involve a range of analyses and research from qualitative descriptions of life-cycle stages to mathematical descriptions of the ecological mechanisms.

Specific tasks anticipated in PATH for 1999 are outlined below according to species. In all cases the retrospective and prospective analysis will use the tools detailed in Objectives 2 through 8 above.

Tasks involving Spring/summer chinook:

- Complete post-processing and sensitivity analysis of retrospective and prospective analysis
- Complete final decisions analysis
- Complete report on impacts of ocean/climate analysis

Tasks involving fall chinook and steelhead:

- Complete revised retrospective analysis based on analyses of the lifecycle stages outlined in the Objectives
- Complete prospective analyses
- Complete decisions analysis report framework - processing and sensitivity analysis of prospective analysis
- Complete final decisions analysis

Objectives 2 and 3 concern analysis of smolt and adult migrations through the river system and involve calibration and validation of movement, survival and exposure of the fish to critical water quality indicators. Movements of fish and changes in water quality properties in the hydrosystem will be formulated in terms of the first principles of the mechanisms involved. Fish movement depends on flow and behavior as determined by fish experiences and physiology. The movement of water quality indicators, (i.e temperature and gas) will be described by advective-diffusive equation in the passage models that moves water parcels through the system. Model predictions are validated by comparison with PIT tag studies giving travel time, survival and smolt-to-adult return ratios.

Objectives 4 relates to the analysis of the impact of drawdown on redds and the success of emergence of fry according to the water flows and water quality and river bed properties. These tools will be used to expand the retrospective and prospective analysis of drawdown issues for all species. A key modeling tool will be the HEC-6 sediment movement model. The model will use information being collected under USACE programs on the sediment properties in the reservoirs.

Objective 5 involves analysis of the impacts of ocean conditions on stocks. This work involves analysis of the historical patterns of west surface currents using the OCSURS current model and the limited information on the distribution of predators and plankton available in historic records. The approach is to determine if any plausible patterns of currents and ecological regimes emerge from simulation analysis that can explain the decadal scale and latitudinal patterns of stock productivity from California to Alaska. If patterns can be recognized they can be used to better define climate interactions in the retrospective analysis and the results will be used to improve the simulation of climate in the prospective analysis.

Objective 6 will be used to develop a prospective analysis of the harvest strategies for fall chinook (and potentially steelhead). To develop stock selective harvest schemes the migrations and survival of fish between fishing regions must be defined and calibrated

with data. The technique will uses Bayesian monte carlo techniques to develop probability distributions of fish migration and harvest. The current work is being carried out in a project with Dr. Newman at the University of Idaho under NMFS funding. In 1999 the model will be a viable tool to evaluate stock selective harvest policies.

Objective 7 involves modeling of the dynamics of disease in wild and hatchery salmon over their lifecycle. Four elements are anticipated: 1) reviewing data on fish disease distributions and transmission rates; 2) modeling the dynamics of disease transmission; 3) evaluating the response of the model to determine if any disease management strategies may be effective; and 4) identifying an experimental approach to evaluate the strategies.

f. Facilities and equipment.

The CRiSP project is conducted at the University of Washington off-campus due to the demolition of the CQS building on campus. Completion of this project involves maintenance of our library, computer facilities, and data bases. This information system is fully functioning at Columbia Basin Research. Minor replacement of computer facilities and upgrading of software is anticipated, but no major high-cost equipment will be needed.

g. References.

Anderson, J.J. 1996a. Review of the influence of climate on salmon. In Plan for Analyzing and Testing Hypotheses (PATH): Final report on retrospective analyses for fiscal year 1996. Compiled and edited by ESSA Technologies Ltd., Vancouver, B.C.

Anderson, J.J. 1996b. Decadal scale climate pattern and salmon survival: Indicators, interaction and implications. Paper presented at the NMFS Workshop on Estuaries and Ocean Survival of Salmon, Newport, Oregon.

Anderson, J.J. (in press). Decadal climate cycles and declining Columbia River salmon. In Proceedings of the Sustainable Fisheries Conference, Victoria, B.C," ed. E. Knudsen. American Fisheries Society Special publication no. 2x. Bethesda, MD.

Anderson, J.J. 1997. Influence of Climate on Fish, Review. Kah-Nee-Tah Meeting.

Anderson, JJ. (in press). Decadal climate and declining Columbia River salmon. In E Knudsen (ed.), Proceedings of the Sustainable Fisheries Conference, Victoria, B.C. American Fisheries Society Special publication no. 2x. Bethesda, Maryland.

Anderson, J.J. and R.A. Hinrichsen. 1996. Climate indicators to salmon survival. Paper presented at the PICES meeting, 18 October, Nanaimo, B.C.

Anderson, J.J. and Hinrichsen, R.A. 1997a. A Suite of Alternative Hypotheses Using A Passage Model in a Bayesian Framework. Anderson and Hinrichsen. June 11.

Anderson, J.J. and Hinrichsen, R.A. 1997b. Retrospective Analysis for the alpha model. June 25.

Anderson, J.J. and Hinrichsen, R.A. 1997c. Prospective Analysis for the alpha model. July 28.

Anderson, J.J., Paulsen, and Hinrichsen, R.A. 1997. Comparison of MLE Spawner-Recruit Models. May 8.

Hayes, J. 1997. Snake River spring chinook survival 1966-1983. Kah-Nee-Tah Meeting.

Hinrichsen, R.A., J.J. Anderson, G.M. Matthews and C.C. Ebbesmeyer 1997. Effects of the Ocean and River Environments on the Survival of Snake river Stream-Type Chinook. U.S. Department of Energy Bonneville Power Administration Report.

Shaw, P. 1996. Gas Saturation and Sensitivity Analysis Using CRiSP Dissolved Gas Abatement Technical Report, Phase 1, Appendix J. USACE.

Shaw, P. 1997. Temperature Analysis Tools at Columbia Basin Research. Columbia/ Snake River Mainstem Temperature Workshop (EPA) Nov. 6-7.

Zabel, R. 1996. Discussion of CRiSP model parameters for Nitrogen Mortality. working paper distributed to PATH group.

Zabel, R. 1997. Further Analysis of Bias in Stock-Recruit Data Sets; working paper distributed to PATH group.

Zabel, R. 1997b. A Summary of the Flow/Travel Time Relationship in CRiSP. Kah-Nee-Tah meeting.

Section 8. Relationships to other projects

This project is an integral part of the PATH process. Much of the framework of alternative hypotheses has been developed through this project. In particular, the mathematical equivalents of several NMFS hypotheses have been formulated in this project.

Section 9. Key personnel

The principal investigator for this project is Dr. James J. Anderson.

Curriculum Vitae: James J. Anderson

Associate Professor (WOT)
Fisheries Research Institute and Center for Quantitative Science in Forestry, Fisheries and Wildlife
College of Ocean and Fisheries Sciences

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Teaching Activities:

Graduate course in modeling organism dynamics (QSCI 551)
Graduate course in Ecosystem models (QSCI 550)

Students Receiving Degrees: Three in M.S. Fisheries, Two in M.S. Quantitative Ecology & Resource Management, and Two in Ph.D. Quantitative Ecology & Resource Management.

Current Research Projects:

Bonneville Power Administration (Funding level: $6 million): Developing computer models for management of Columbia River hydroelectric and fisheries agencies.

U.S. Army Corps of Engineers (Funding level: $600,000): Developing analysis and computer models for the impact of gas bubble disease on migrating salmon.

National Marine Fisheries Service (Funding level: $300,000):

1) Studying mortality processes of juvenile salmon in tributaries
2) Developing a multi-species multi-regional salmon harvest model

Honors and Awards:

1) Research Faculty Fellowship, College of Ocean and Fishery Sciences 1985, 1989.
2) Special Recognition for participation in the U. S. Fish and Wildlife Service Fish Passageways and Division Structures course in 1990.
3) Nomination for Computerworld Smithsonian Awards in programming for the CRiSP computer model College of Ocean and Fishery Sciences Distinguished Research Award, 1996.

Professional Activities: Consulting; Expert Testimony on Fish Migration and Dam Passage; Guest Speaker

There is a total of 47 Publications. The 1997 Publications include:

Anderson, J.J. (in press) Decadal Climate Cycles and Declining Columbia River Salmon. Proceedings of the sustainable Fisheries Conference, Victoria B.C., Canada, 1996. Eric Knudsen, Editor. Special publication of the American Fisheries Society.

Anderson, J.J. 1997. Decadal Scale Climate Pattern and Salmon Survival: Indicators, Interactions and Implications, Estuarine and Ocean Survival of Northwest Pacific Salmon Workshop NMFS 1997.

Beer, W.N. and J.J. Anderson. 1997. Modeling the Growth of Salmonid Embryos. Journal of Theoretical Biology. 189(3) 297-306.

Zabel, R.W. and J.J. Anderson. 1997. A Model of the Travel Time of Migrating Juvenile Salmon, with an Application to Snake River Spring Chinook. North American Journal of Fisheries Management. 17:93-100.

Section 10. Information/technology transfer

Models, documentation correspondence for this project are available on the World Wide Web at http://cqs.washington.edu. Selected works are published in the reviewed literature or as BPA reports.